Technical Exchange: HLA-C2 Experiment

Mr. Mike Lightner, AEgis Research Corp.

8 October 1997

Outline

- **Experiment Design → Execution**
  - **Participants**
  - **Approach**
  - **FEDEP**
    - **Key Objectives**
    - **Scenario**
    - **Design Aspects**
    - **Development (FOM)**
    - **Execution Environment**
  - **Insights/Lessons Learned**

HLA C2 Experiment
Participating Agencies

AGENCY	ROLE	POC
DMSO	Activity Lead	Maj Steve Zeswitz
JSIMS	Testbed, Admin.	Dave Pratt, Bill Hudgins
ESC	Air Warfare	Tim Rudolph, Tony Luches
TRAC	Land Warfare	Kent Pickett, Jack Ogren
SPAWAR	Naval Warfare	CDR Ormsen, Bill Stevens
NRaD	MRCI / C2	Tom Tiernan, Cindy Keune
AEgis	System Integ.	Bill Waite, Mike Lightner

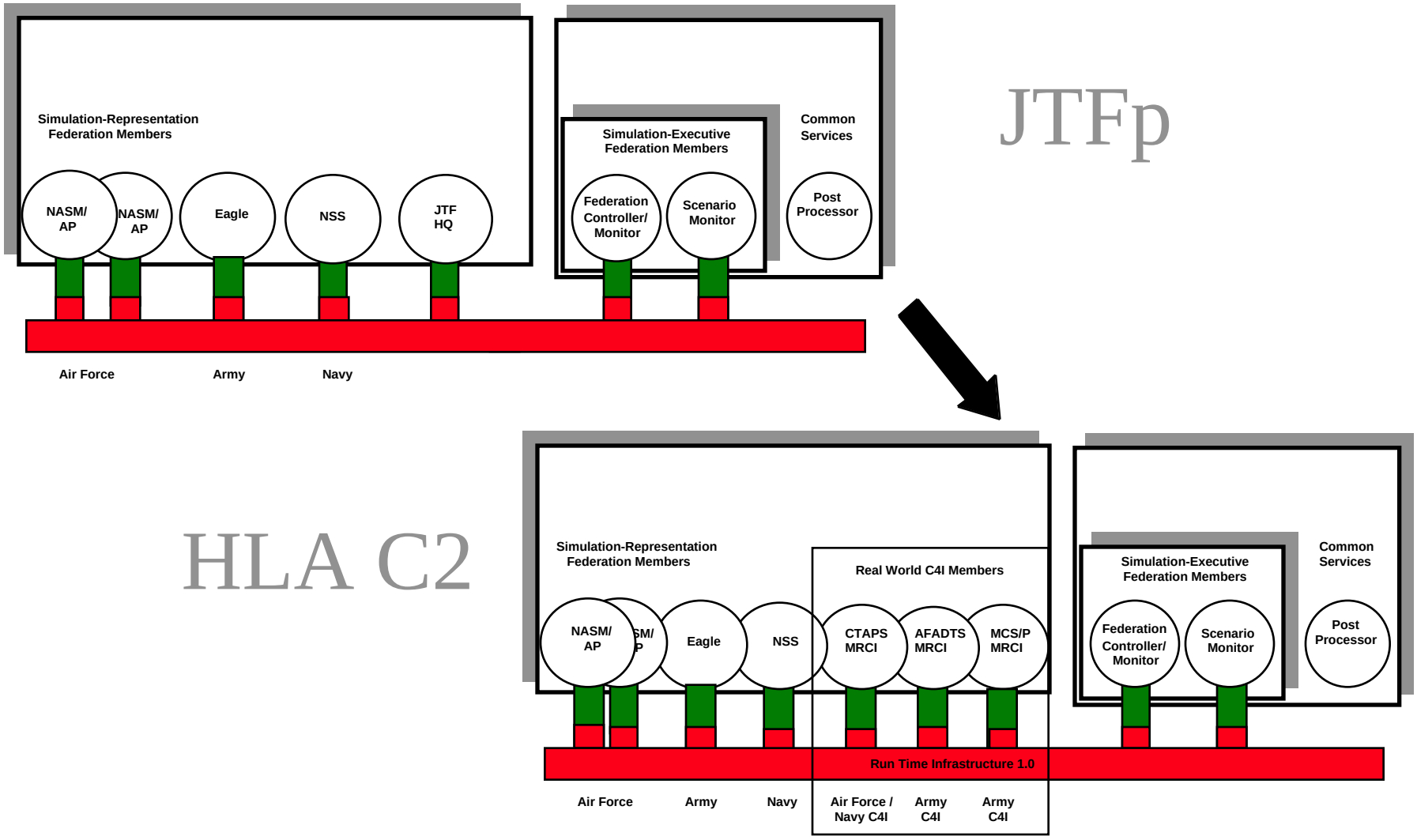
HLA C2 Experiment
Key Personnel

AEgis:	**Mike Lightner, Jean Graffagnini, Dannie Cutts, Judy Schandua, Conrad Housand, Anthony Franklin, Ron Sell, Bonnie Tillman**
Eagle:	**Jack Ogren**
NASM/AP:	**Tony Luches, Ray Mandery, Steve Jackson, Jeff Okerson, Eric Ngouyassa, Adam Sulesky**
NSS:	**Jeff Jones, Gary Blank**
MRCI:	**Cindy Keune, John Everett, Mike Hieb, Ed Ashley, Bruce Clay, Mike Lee, Larry Griggs**

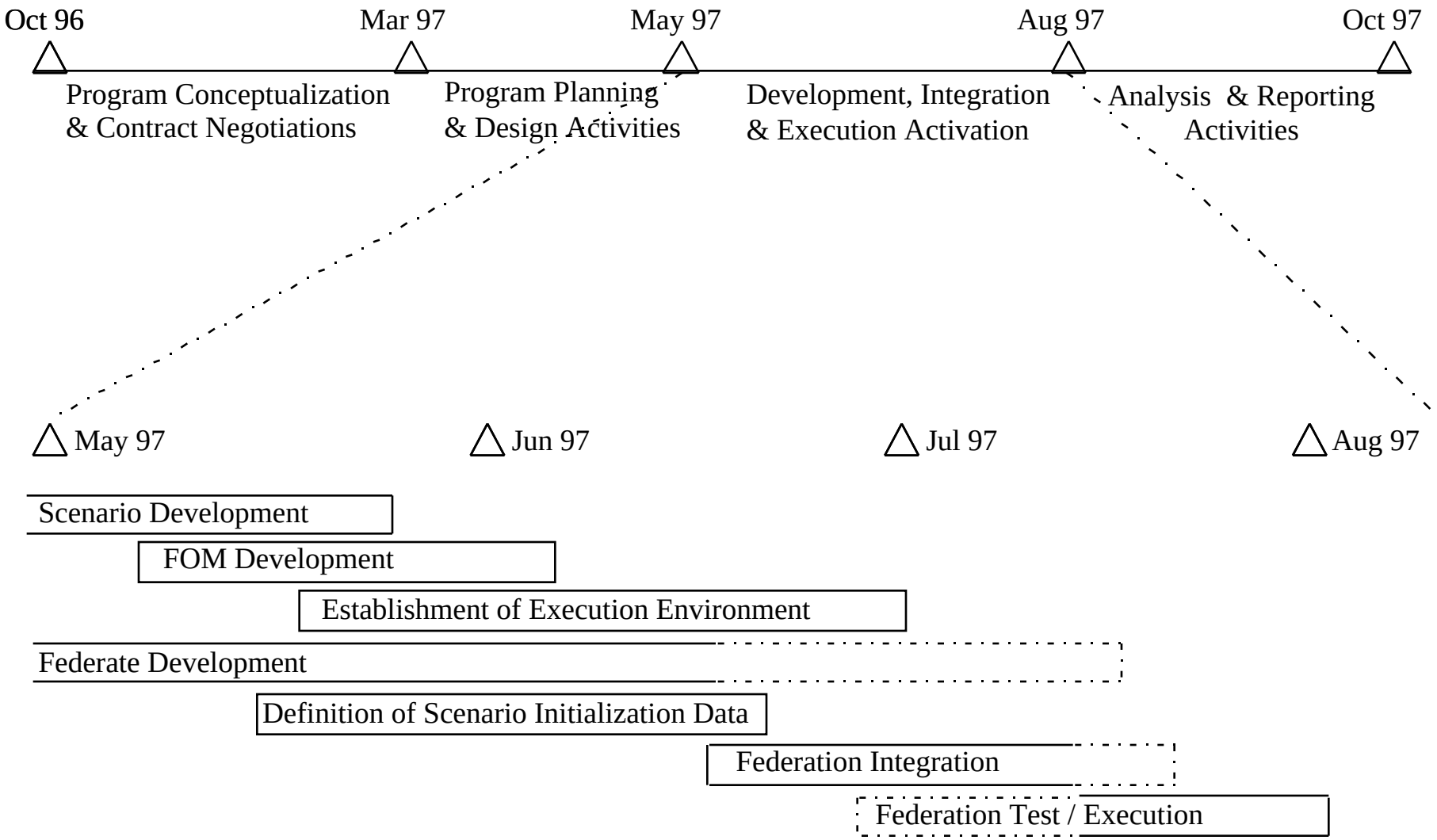
HLA C2 Experiment Approach

- **Collaborative distributed planning, design and development using integrator to facilitate the process.**
- **Central integration, testing and analysis in Orlando testbed.**
- **Using FEDEP as high level guidance capture actual process used and assess FEDEP guidance.**

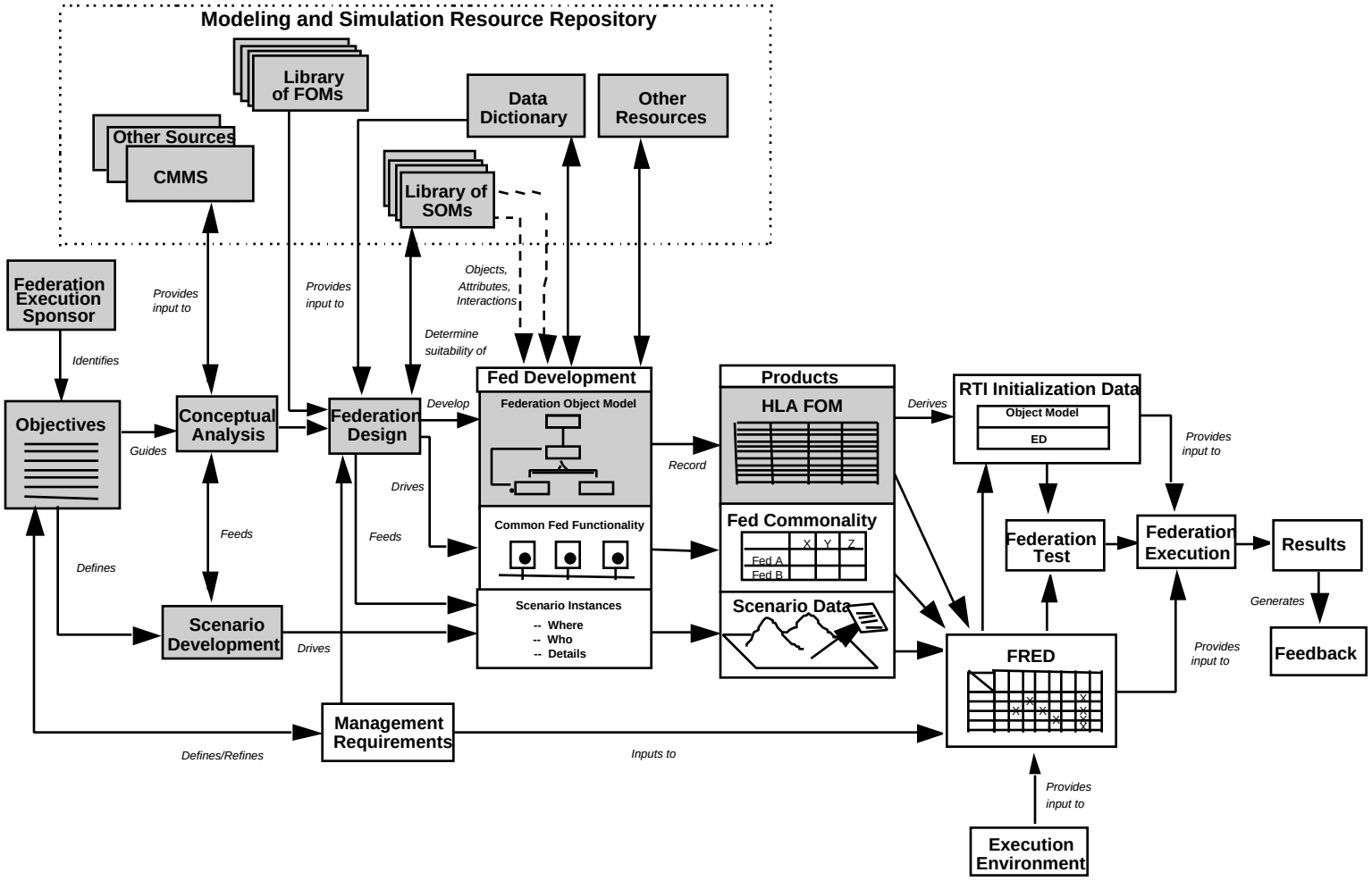
HLA C2 Experiment Approach



HLA C2 Experiment
Timeline of Activities



HLA C2 Experiment
FEDEP



Federation Development and Execution Process Model

HLA C2 Experiment
Key Objectives

- **Provide insight and feedback on HLA processes in supporting extension of HLA Federations and Federates.**
- **Extend experience base for the HLA process model by exploring integration of real-world C2 aspects and components in HLA federations.**
- **Assess what's required to make a C2 system an HLA federate and the impact of adding such a federate to an HLA federation.**
- **Assess premise and functionality of MRCI and evaluate the extensibility and portability of the MRCI software.**
- **Demonstrate and assess use of MOM in support of federation management and automated tools in support of federation development and execution.**
- **Demonstrate ability to send realistic C2 messages between real-world C2 entities and simulation federates and the mechanisms for doing so.**

HLA C2 Experiment
Graphical Scenario View

HLA C2 Experiment
Scenario Highlights

Event Descriptor	Initiator	C2 Message Information	Receipent
Scenario Air - Initial	**INIT**	**C2 messages**	**RECE**
Joint commander sends Air Tasking Order (ATO) and Airspace Control Order (ACO)	CTAPS	**Interaction**: AIR TASKING ORDER (Message #1500) AIRSPACE CONTROL ORDER (Message # 1501)	NSS NASM
Wings schedule missions & send mission status estimates per mission	NASM/AP	**Interaction:** MISSION STATUS ESTIMATE (Message #1700)	
Red aircraft (SU-25s) launch and proceed to target Blue airbase	NASM/AP		NASM/AP
Blue air defense units engage Red air at border crossing	Eagle		NASM/AP
Red aircraft (SU-25s) attack Blue Airbase	NASM/AP		NASM/AP
Blue Airbase reports Airbase status.	NASM/AP	**Interaction:** AIRBASE STATUS (Message #1703)	CTAPS
Red aircraft attack Blue ground units	NASM/AP		EAGLE
E2C launch to orbiting location,	NSS	**Interaction:** MISSION STATUS ACTUAL (Message #1701)	Eagle CTAPS
Air refueling aircraft (KC-135, and S-3B) launch to refueling orbit	NASM/AP NSS	**Interaction:** MISSION STATUS ACTUAL (Message #1701)	NASM/AP NSS Eagle CTAPS
AWACS cap aircraft launch to AWACS cap locations	NASM/AP	**Interaction:** MISSION STATUS ACTUAL (Message #1701)	Eagle NSS CTAPS NASM/AP
Blue strike aircraft take off from carrier and airbase (phased based on the ATO)	NSS NASM/AP	**Interaction:** MISSION STATUS ACTUAL (Message #1701)	Eagle NASM/AP NSS CTAPS
Blue air proceeds to pre-assigned targets (SEAD, INTERDICTION, CAS)	NSS NASM/AP		Eagle NASM/AP NSS
Scenario Air - ATO Goal 1 Phase 1: SEAD phase	**INIT**	**C2 messages**	**RECE**
Air defense suppression AC attack Air defense and fixed C2 sites	NSS NASM/AP		Eagle
Red air defense units engage Blue air in defense of Air defense sites and the airfield	Eagle		NSS NASM/AP
Blue Airbases report on Airbase status as aircraft return Blue units report on mission status	NSS NASM/AP	**Interaction:** AIRBASE STATUS (Message #1701), AIR MISISON REPORT (Message #1707)	CTAPS
Scenario Air ATO Goal 1 Phase 2: - Airbase Attack Phase			
Ground attack AC attack airfield	NSS NASM/AP		NASM/AP NSS
Red air defense units engage Blue air in defense of Air defense sites and the airfield	Eagle		NSS NASM/AP

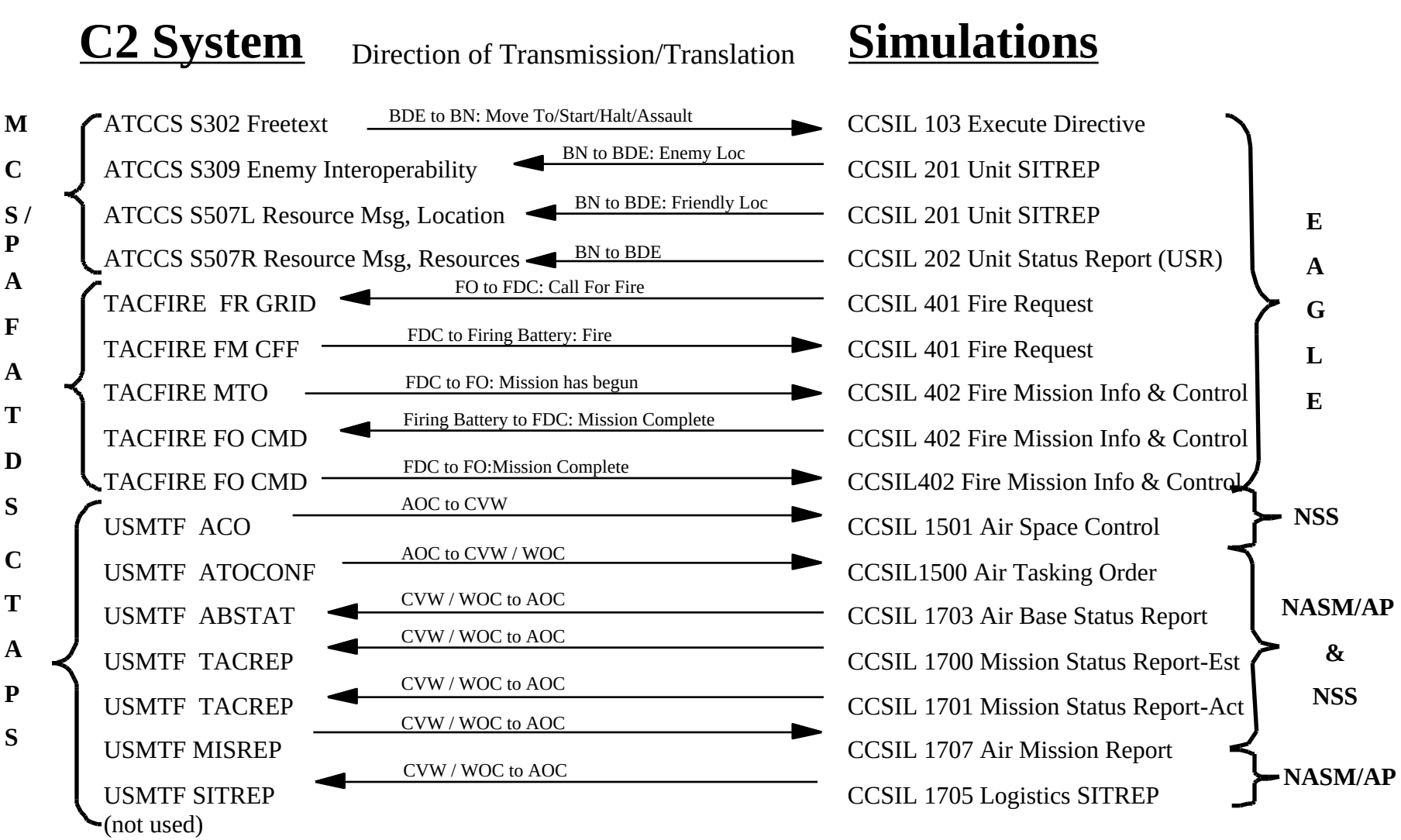
HLA C2 Experiment
Scenario Highlights

Event Descriptor	Initiator	C2 Message Information	Receipent
Blue Airbases report on Airbase status as aircraft return	NSS NASM/AP	**Interaction:** AIRBASE STATUS (Message #1701), AIR MISISON REPORT (Message #1707)	CTAPS
Scenario Air ATO Goal 2 - Interdiction	**INIT**	**C2 messages**	**RECE**
Ground attack AC attack Moving Divisions	NSS NASM/AP		Eagle
Red air defense units engage Blue air in defense maneuver units.	Eagle		NSS NASM/AP
Blue Airbases report on Airbase status as aircraft return	NSS NASM/AP	**Interaction:** AIRBASE STATUS (Message #1701), AIR MISISON REPORT (Message #1707)	CTAPS
Scenario Air ATO Goal 3 - CAS	**INIT**	**C2 messages**	**RECE**
Ground attack AC CAS aircraft arrive at IP and orbit	NSS		
MSF G3 requests Close Air Support (CAS).	MCS/P		Eagle
Attack Aircraft respond to CAS requests from MSF	Eagle		NSS
Red air defense units engage Blue air in defense maneuver units.	Eagle		NSS
Blue Airbases report on Airbase status as aircraft return	NSS	**Interaction:** AIRBASE STATUS (Message #1701), AIR MISISON REPORT (Message #1707)	CTAPS
Scenario Ground	**INIT**	**C2 messages**	**RECE**
MSF G3 issues order to begin breakout	MCS/P	**Interaction:** Executive Directive (Message #103)	Eagle
· MSF G3 assesses the Brigades situation.	MCS/P		
· MSF G3 receives situation reports from the subordinate units.	Eagle	**Interaction:** Unit Situation Report (Message #201)	MCS/P
· MSF G3 receives enemy spot reports from subordinates and Intel assets.	Eagle	**Interaction:** Unit Situation Report (Message #201)	MCS/P
· MSF G3 receives equipment status reports from the subordinates	Eagle	**Interaction:** Unit Status Report (Message #202)	MCS/P
· MSF G3 develops the Intel Picture by directing his Intel assets.			
· Send Frag. Orders to deploy RPV's to develop the enemy situation.	MCS/P	**Interaction:** FRAG. Order (Message #103)	Eagle
· MSF G3 receives enemy spot reports from subordinates and Intel assets.	Eagle	**Interaction:** Unit Situation Report (Message #201)	MCS/P
· MSF G3 directs his maneuver forces to attack defending enemy.			
· Send Frag. Orders to redirect deploying battalions to attack the enemy from the flanks.	MCS/P	**Interaction:** FRAG. Order (Message #103)	Eagle
· Send Frag. Orders to Attack Helicopter Battalions to support the ground combat.	MCS/P	**Interaction:** FRAG. Order (Message #103)	Eagle

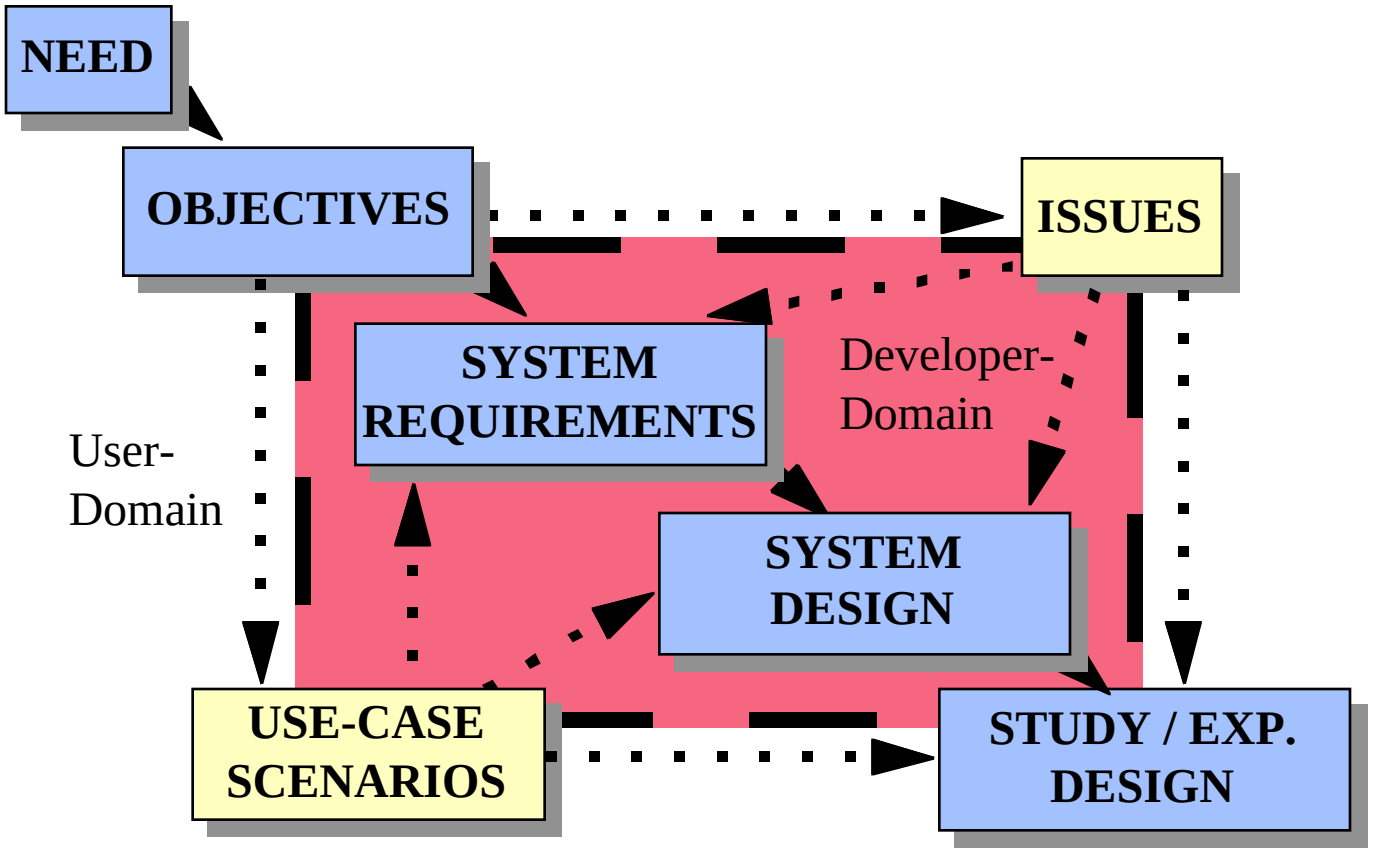
HLA C2 Experiment
Scenario Highlights

Event Descriptor	Initiator	C2 Message Information	Recipient
· MSF G3 receives situation reports from the subordinate units.	Eagle	**Interaction:** Unit Situation Report (Message #201) **Interaction:** Unit Status Report (Message #202)	MCS/P
· MSF G3 directs and requests information from subordinates	MCS/P	**Interaction:** Execute directive (Message #103) **Interaction:** Report Request (Message #203)	Eagle
· MSF G3 directs Intel assets to provide security			
· Send Frag. Orders to RPV's to observe exposed friendly flank positions as the Brigade is reoriented on attacking the enemy	MCS/P	**Interaction:** FRAG. Order (Message #103)	Eagle
· MSF G3 receives enemy spot reports from subordinates and Intel assets.	Eagle	**Interaction:** Unit Situation Report (Message #201)	MCS/P
· MSF G3 directs combat maneuver support.			
· Send Frag Orders to the Field Artillery & Air Defense Artillery units positioning them to support the attack.	MCS/P	**Interaction:** FRAG. Order (Message #103)	Eagle
· MSF G3 receives situation reports from the subordinate units.	Eagle	**Interaction:** Unit Situation Report (Message #201) **Interaction:** Unit Status Report (Message #202)	MCS/P
· MSF Fire Support Element (FSE) monitors FA Status			
· MSF FSE receives status reports from supporting Artillery.	Eagle	**Interaction:** Unit Situation Report (Message #201) **Interaction:** Unit Status Report (Message #202)	AFATDS
· MSF FSE receives situation reports from Fire Support Teams.	Eagle	**Interaction:** Unit Situation Report (Message #201)	AFATDS
· MSF FSE receives Fire Mission requests.			
· Fire requests from the aviation units.	Eagle	**Interaction:** Fire Requests (Message #401)	AFATDS
· Fire requests from the down link RPV station.	Eagle	**Interaction:** Fire Requests (Message #401)	AFATDS
· Nominated Fire requests from the battalions	Eagle	**Interaction:** Fire Requests (Message #401)	AFATDS
· MSF FSE allocates and monitors Fire Missions			
· MSF FSE allocates FM to Bn/Btry	AFATDS	**Interaction:** Fire Requests (Message #401)	Eagle
· MSF FSE receives status of FM	Eagle	**Interaction:** Fire Mission Inf. And control (Message #402)	AFATDS
· MSF FSE receives EOM reports with BDA.	Eagle	**Interaction:** Fire Mission Inf. And control (Message #402)	AFATDS
· MSF G3 requests Close Air Support (CAS).	MCS/P		Eagle
· Orbiting Alert CAS aircraft vector towards tanks	NSS	**Interaction:** Mission Status (Message #1701)	CTAPS, NSS, NASM/AP, Eagle
· Blue CAS aircraft attack Tanks	NSS		Eagle

HLA C2 Experiment
C2 to SIM Interactions



HLA C2 Experiment
System Design



HLA C2 Experiment
Summary of FOM Changes

Changes to Object Class Structure Table

Object	*New/ Updated*	*# Old Subclasses*	*# New Subclasses*
Communications_Object	**New**	**N/A**	**0**

Changes to Interaction Class Structure Table

Interaction	*New/ Updated*	*# Old Subclasses*	*# New Subclasses*
Transmit (IR)	**Updated**	**1**	**2**
Comm_Effects (IR)	**New**	**N/A**	**0**
Maximum_Comm_Effects_Matrix	**New**	**N/A**	**0**
C2_Interaction (IR)	**New**	**N/A**	**13**

Changes to Attribute Table

Object	*New/ Updated*	*# Old Attributes*	*# New Attributes*
Communications_Object	**New**	**N/A**	**12**

HLA C2 Experiment
Summary of FOM Changes

Changes to Parameter Table

Interaction	*New / Updated*	*# Old Parameters*	*# New Parameters*
RequestAirSupport	**Updated**	**3**	**9**
Comm_Effects	**New**	**N/A**	**7**
Maximum_Comm_Effects_Matrix	**New**	**N/A**	**2**
Airspace_Control_Order	**New**	**N/A**	**9**
Air_Mission_Report	**New**	**N/A**	**9**
Airbase_Status	**New**	**N/A**	**9**
Mission_Status_Actual	**New**	**N/A**	**9**
Logistics_SITREP	**New**	**N/A**	**9**
Mission_Status_Estimate	**New**	**N/A**	**9**
Air_Tasking_Order	**New**	**N/A**	**9**
Fire_Mission_Information_and_Control	**New**	**N/A**	**9**
Fire_request	**New**	**N/A**	**9**
Unit_Status_Report	**New**	**N/A**	**9**
Unit_Situation_Report	**New**	**N/A**	**9**
Execute_order	**New**	**N/A**	**9**
Fragmentary_order	**New**	**N/A**	**9**
CAS_contact	**New**	**N/A**	**5**

Changes to Enumerated Datatypes Table

Identifier	*New / Updated*	*# Old Enums*	*# New Enums*
EntityTypeEnum	**Updated**	**30**	**32**
FederateTypeEnum	**Updated**	**5**	**3**
AAWeaponTypeEnum	**Updated**	**6**	**4**
ASWeaponTypeEnum	**Updated**	**5**	**11**

HLA C2 Experiment
Changes to FOM Object Class Structure Table

Class 1	*Class 2*	*Class 3*
Communications_Object		
Player (PS)	AirPlayer (S)	Aircraft (PS)
		Flight (PS)
	GroundPlayer (S)	FixedSite (PS)
		AggregateGroundPlayer (PS)
	AfloatPlayer (PS)	
FederateStatus (PS)		

HLA C2 Experiment
Changes to FOM Interaction Class Structure Table

Interaction 1	*Interaction 2*
Transmit (IR)	RequestAirSupport (IR)
	CAS_contact (IR)
Engage (IR)	AirToAirEngage (IR)
	AirToDiscreteGroundEngage (IR)
	AirToAggregateGroundEngage (IR)
	AggregateGroundToAirEngage (IR)
Comm_Effects (IR)	
Maximum_Comm_Effects_Matrix (IR)	
C2_Interaction (IR)	***Airspace_Control_Order (IR)***
	Air_Mission_Report (IR)
	Airbase_Status (IR)
	Mission_Status_Actual (IR)
	Logistics_SITREP (IR)
	Mission_Status_Estimate (IR)
	Air_Tasking_Order (IR)
	Fire_Mission_Information_and_Control (IR)
	Fire_request (IR)
	Unit_Status_Report (IR)
	Unit_Situation_Report (IR)
	Execute_order (IR)
	Fragmentary_order (IR)
FederationControl (IR)	FedExecute (IR)
	FedInitialize (IR)

HLA C2 Experiment
Changes to FOM Attribute Table

Object	Attribute	Datatype	Cardinality	Units	Resolution	Accuracy	Accuracy Condition	Update Type	Update Condition	Transferrable / Acceptable	Updateable / reflectable
Communications_Object	***Comm_system_ID***	***any***	***1***			***perfect***	***always***	***Conditional***		***N***	***UR***
	Entity_ID	***any***	***1***			***perfect***	***always***	***Conditional***		***N***	***UR***
	Echelon	***any***	***1***			***perfect***	***always***	***Conditional***		***N***	***UR***
	Network_ID	***any***	***1***			***perfect***	***always***	***Conditional***		***N***	***UR***
	Entity_Loc_Lat	***any***	***1***			***perfect***	***always***	***Conditional***		***N***	***UR***
	Entity_Loc_Long	***any***	***1***			***perfect***	***always***	***Conditional***		***N***	***UR***
	Entity_Loc_Alt	***any***	***1***			***perfect***	***always***	***Conditional***		***N***	***UR***
	Frequency	***any***	***1***			***perfect***	***Always***	***Conditional***		***N***	***UR***
	Bandwidth	***any***	***1***			***perfect***	***always***	***Conditional***		***N***	***UR***
	Encryption_Key	***any***	***1***			***perfect***	***always***	***Conditional***		***N***	***UR***
	Apply_Degradation	***any***	***1***			***perfect***	***always***	***Conditional***		***N***	***UR***
	Net_Access_Time	***any***	***1***			***perfect***	***always***	***Conditional***		***N***	***UR***
Player	entity_name	string	1			perfect	always	Static		N	UR
	federate_id	FederateTypeEnum	1	N/A	N/A	N/A	N/A	Static		N	UR
	affiliation	TeamEnum	1	N/A	N/A	N/A	N/A	Static		N	UR
	motion_type	MotionTypeEnum	1	N/A	N/A	N/A	N/A	Static		N	UR
	voice_nets	boolean	MAX_VOICE_NETS		TRUE, FALSE	perfect	always	Static		N	UR
	jtids_nets	boolean	MAX_JTIDS_NETS		TRUE, FALSE	perfect	always	Static		N	UR
	trap_tre	boolean	1		TRUE, FALSE	perfect	always	Static		N	UR
	commander_type	CommanderTypeEnum	1	N/A	N/A	N/A	N/A	Static		N	UR

HLA C2 Experiment
Changes to FOM Parameter Table

Interaction	Parameter	Datatype	Cardinality	Units	Resolution	Accuracy	Accuracy Condition
RequestAirSupport	***From***	***long***	***1***			***perfect***	***always***
	To	***long***	***1***			***perfect***	***always***
	send_time	***float***	***1***	***seconds***	***0.1 seconds***	***perfect***	***always***
	comms_system	***CommSysTypeEnum***	***1***	***N/A***	***N/A***	***N/A***	***N/A***
	net_number	***unsigned short***	***1***		***1***	***perfect***	***always***
	requestor_id	unsigned long	1		1	perfect	always
	target_id	unsigned long	1		1	perfect	always
	time_on_target	float	1	seconds	1 seconds	600 seconds	always
	target_lat	***float***	***1***	***degrees***	***0.00001 degrees***	***0.00001 degrees***	***always***
	target_lng	***float***	***1***	***degrees***	***0.00001 degrees***	***0.00001 degrees***	***always***
	target_type	***any***	***1***			***perfect***	***always***
	to_federate	***unsigned long***	***1***			***perfect***	***always***

HLA C2 Experiment
Changes to FOM Parameter Table

Interaction	Parameter	Datatype	Cardinality	Units	Resolution	Accuracy	Accuracy Condition
Comm_Effects	*Message_ID*	*unsigned long*	*1*			*perfect*	*always*
	Time_Sent	*any*	*1*			*perfect*	*always*
	Sender_ID	*any*	*1*			*perfect*	*always*
	Receiver_id	*any*	*1*			*perfect*	*always*
	Bit_Error_Rate	*any*	*1*			*perfect*	*always*
	Latency_Time	*any*	*1*			*perfect*	*always*
	Other_Effects	*any*	*1*			*perfect*	*always*
Maximum_Comm_Effects_Matrix	*Receiver_ID*	*any*	*1*			*perfect*	*always*
	Max_Comm_Effects_Vector	*any*	*1*			*perfect*	*always*
Airspace_Control_Order	*CCSIL_msg_type*	*string*	*1*			*perfect*	*always*
	Message_ID	*string*	*1*			*perfect*	*always*
	Comm_system_ID	*string*	*1*			*perfect*	*always*
	Sender_ID	*string*	*1*			*perfect*	*always*
	Receiver_list	*string*	*1*			*perfect*	*always*
	Time_Sent	*float*	*1*			*perfect*	*always*
	Transmission_Type	*any*	*1*			*perfect*	*always*
	Message_size	*unsigned short*	*1*			*perfect*	*always*
	CCSIL_msg	*any*	*1*			*perfect*	*always*
CAS_contact	*From*	*long*	*1*			*perfect*	*always*
	To	*long*	*1*			*perfect*	*always*
	send_time	*float*	*1*	*seconds*	*0.1 seconds*	*perfect*	*always*
	comms_system	*CommSysTypeEnum*	*1*	*N/A*	*N/A*	*N/A*	*N/A*
	net_number	*unsigned short*	*1*			*perfect*	*always*

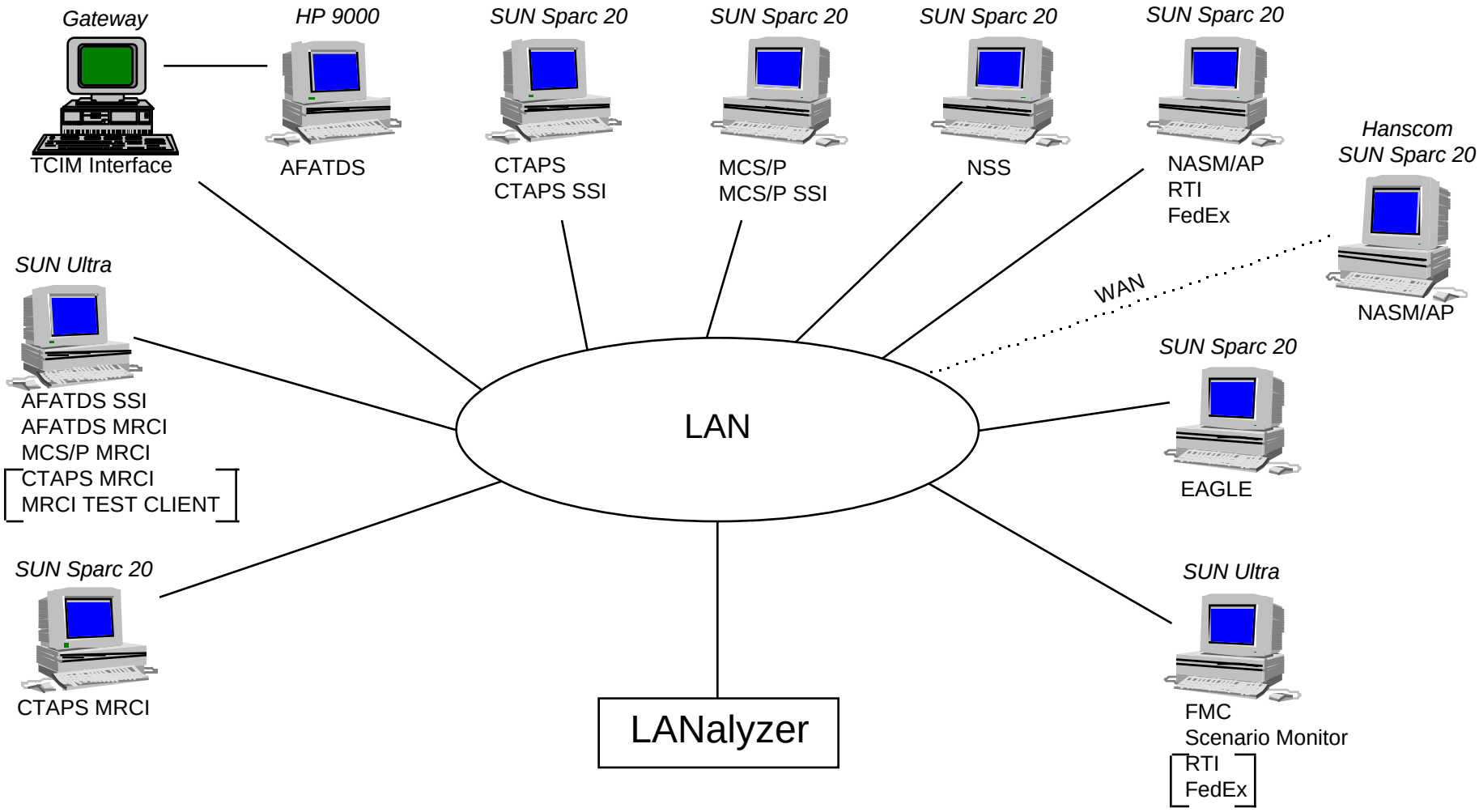
HLA C2 Experiment
Changes to FOM Enumerated Data Type Table

Identifier	Enumerator	Representation
EntityTypeEnum	MIG25	2
	LHX	***32***
	AH64	***33***
	M1	***34***
	FST	***35***
	FST_FLIR	***36***
	BMP	***37***
	ITV	***38***
	IFV	***39***
	BMP_FLIR	***40***
	AFAS	***41***
	MM122_SP_HOW	***42***
	MM122_MORT_B	***43***
	STINGER	***44***
	PIVAD	***45***
	ZSU_X	***46***
	SAX_15	***47***
	BLUE_TRUCK	***48***
	RED_TRUCK	***49***
	Q_36	***50***
	SMALLFRED	***51***
	C2VEH	***52***
	FA18	***53***
	F14	***54***
	CVN	***55***
	CONTROL_TOWER	***56***
	HANGAR	***57***
	RUNWAY	***58***
	F16C	***59***
	E3A	***60***
	SU25	***61***
	F15C	***62***
	E3C	***63***
FederateTypeEnum	EAGLE	1
	NSS	2
	NASM_1	3
	NASM_2	4
	FED_CONTROLLER	5
	MRCI_AFATADS	***6***
	MRCI_CTAPS	***7***
	MRCI_MCSP	***8***

HLA C2 Experiment
Changes to FOM Enumerated Data Type Table

AAWeaponTypeEnum	SIDEWINDER	1
	AIM9	2
	AIM12	3
	PHOENIX	4
	APHID	5
	ATOLL	6
	AIM7	***7***
	AIM54	***8***
	AIM120	***9***
	AA6	***10***
ASWeaponTypeEnum	BOMB_500LB	1
	HARPOON	2
	HARM	3
	MAVERICK	4
	BIGBOY	5
	SCUD	***6***
	GBU24	***7***
	DURENDAL	***8***
	AGM65G	***9***
	AGM88	***10***
	KG250	***11***
	MK84	***12***
	AGM65	***13***
	CBU99	***14***
	CBU87	***15***
	GBU12	***16***

HLA C2 Experiment
System Layout



HLA C2 Experiment
Execution Details Chart

SYSTEM	CPU						Operating System			Network Configuration	
Hostname	**Site**	**Type**	**No. of Proc.**	**Speed**	**Memory**	**Disk Storage**	**Classification Level**	**Base Revision**	**Applied Patches**	**LAN IP Address**	**WAN (DSI) IP Address**
hlac2-cntrl	JSIMS Lab	Sun Ultra 1	1	167Mhz	128 Mb	6.3 GB	Unclassified	Solaris 2.5		207.132.79.41	199.57.91.14
hlac2-eagle	JSIMS Lab	Sun SPARC 20	1	75 Mhz	160 Mb	4.2 GB	Unclassified	Solaris 2.5		207.132.79.40	199.57.91.13
hlac2-nss	JSIMS Lab	Sun SPARC 20	1	75 Mhz	160 Mb	4.2 GB	Unclassified	Solaris 2.5		207.132.79.43	199.57.91.12
hlac2-nasm-ap	JSIMS Lab	Sun SPARC 20	1	75 Mhz	160 Mb	5 GB	Unclassified	Solaris 2.5		207.132.79.42	199.57.91.11
mrci3	JSIMS Lab	Sun Ultra 1	1	167Mhz	256 Mb	9 GB	Unclassified	Solaris 2.5.1		207.132.79.46	199.57.91.21
cowboy	JSIMS Lab	Sun SPARC 20	1	60 Mhz	128 Mb	5.3 GB	Unclassified	SunOS 2.4.1		207.132.79.45	199.57.91.20
hlac2 – afatds2	JSIMS Lab	HP 735	1	125 Mhz	128 Mb	2 GB	Unclassified	SunOS 4.1.3		207.132.79.24	199.57.91.17
hla2 – afatds1	JSIMS Lab	Pentium II	1	200 Mhz	32 MB	2 GB	Unclassified	SCO UNIX 5.0		207.132.79.48	199.57.91.16
traveler	JSIMS Lab	Sun SPARC 20	1	60 Mhz	128 Mb	4.2 GB	Unclassified	Solaris 2.5.1		207.132.79.23	199.57.91.23
ctaps - svr	JSIMS Lab	Sun SPARC 20	1	60 Mhz	128 Mb	4.2 GB	Unclassified	Sun OS 4.1.3		207.132.79.47	199.57.91.15
Birch	ESC	Spare – 20	2	75 Mhz	96 MB	4 GB	Unclassified	Solaris 2.5.1	10300 6-03	N/A	199.56.79.145

HLA C2 Experiment
Insights / Lessons Learned

<u>Insight/Lesson Learned</u>: *The HLA C2 Experiment identified four primary areas in which the current documented Federation Development and Execution Process (FEDEP) needs to evolve in order to address and support federation extensions. These are:*

- **It needs to address the different purposes of federation extension and how these purposes lead to different decision paths within Federation Design and Federation Development phases.**
- **It needs to sufficiently define or guide the system engineering activities required to integrate an extended federation.**
- **It needs to allow for either the inclusion of federates' inputs during the Federation Design phase or describe how the impact of their decisions during the Federation Development phase migrate back to the Federation Design, Scenario Development and Conceptual Analysis phase.**
- **It needs to properly depict continual, cyclic, and concurrent processes within Federation Design and Federation Development phases.**

HLA C2 Experiment
Insights / Lessons Learned

Insight/Lesson Learned: ***Impacts to federate code due to the extension of federation membership or changes in RTI version (resulting from interface specification updates) can be minimized by employing flexible, modular code design.*** *Such design will ultimately promote the re-use of federate code.*

Insight/Lesson Learned: *Each phase of the Federation Development and Execution Process (FEDEP) produces artifacts which in some cases depend upon the products from previous phases and in most cases feed products in later phases. The tool set brought to bear needs to aid the user in the production of these products and the persistent capture of them to support later phases and documentation of the overall process.* ***Tools should be selected for each phase of the process such that they compliment each other and come together to form an integrated development and execution environment which serves all aspects and agents in the FEDEP*.**

HLA C2 Experiment
Insights / Lessons Learned

Insight/Lesson Learned: ***In order for a federation management component to provide adequate management to a federation execution, it should have access to more than just the MOM information.*** *While very useful, the MOM information is not sufficient to provide comprehensive federation management. In addition to the MOM, access to FOM specific information is also required.*

Insight/Lesson Learned: *Given that the MRCI design and prototype implementation constitute a generic and reusable interface,* ***then the basic premise that such an interface can be used to effect HLA compliant simulations interoperating with real-world C4I equipment for the purpose of C2 activities in HLA federations, is true.***

HLA C2 Experiment
Insights / Lessons Learned

Insight/Lesson Learned: ***As the number of C2 messages and message formats rise, the complexity of any generic C2 interface will increase dramatically***. *In either a point-to-point or generic interface, complex message mappings will have to be accomplished. During the HLA C2 Experiment, modifications of the MRCI configuration files to handle changes to message mappings were complicated and time consuming.*

Insight/Lesson Learned: ***Selection of simulations which closely follow real-world C2 methodologies is key to minimizing SOM and code modifications and insuring successful development of a federation involving real-world C2.*** *The Eagle, NSS and NASM/AP simulations used in the HLA C2 Experiment all employ C2 methodologies which closely map to the real-world and thus were very compatible with the C2 systems used in the experiment.*

HLA C2 Experiment Recommendations

Recommendation: As part of its evolution, add appropriate detail in all areas of the FEDEP to insure the process drives out all issues related to federation extension and the inclusion of real-world/“live” federates at the appropriate time.

Recommendation: The development of tools which support all phases of the FEDEP and can be brought together to form an integrated development and execution environment for HLA federations should be encouraged.

Recommendation: As the MOM evolves, continue to explore management functionality needs of federations and add such functionality as appropriate. Federation management tools should incorporate FOM specific information in addition to the MOM information.

Recommendation: An analysis of the FOM information significance to all areas of the FEDEP should be conducted and the lessons learned used to expand the file formats supported by the OMDT.

HLA C2 Experiment Recommendations

Recommendation: Further investigations into just what constitutes a generic and reusable C2 to Sim interface are needed. Issues on how complex such an interface will get and when it stops being cost efficient should be explored in order to determine the most effective application and use of such interfaces. Any such studies/analyses should include comparisons with other systems and/or approaches.

Recommendation: In order to determine the most appropriate mechanisms for implementing interfaces between simulations and real-world C2 systems, **a complete analysis of all paths of information flow and the actions that occur to the information across those paths is required**. Investigations should be conducted to determine the total information set required to provide effective environments for the purpose at hand; where that information comes from in a real-world scenario; and how that information can be provided in the simulation environment. This insight can then be used to determine whether issues need to be addressed on the simulation side, the real-world C2 system side, or both.

HLA C2 Experiment Recommendations

Recommendation: **Further investigations should be conducted to determine how C4I to Sim interfaces might incorporate time management services in a way that would allow them to support federations requiring "logically timed" executions**. While it may not make sense for human operators to attempt processing messages at faster than real-time rates, it might be beneficial for a federation to be able to support periods of faster than real-time execution in support of focused training, testing, and/or analysis.

Recommendation: As new CCSIL message types are being developed and existing messages are being modified they should be examined to ensure that they are modeling the full content of the "Real-World" C2 messages. **Lessons learned from development and use of CCSIL need to be applied to development of any C2 DIF.** Where its unclear whether certain message or information types are adequately supported, experiments should be conducted using HLA federations to obtain the insights and data needed to determine the exact nature of any shortfall and what actions should be taken to overcome them.